NASA RELIABILITY PREFERRED PRACTICES FOR DESIGN AND TEST

NASA Technical Memorandum 4322A

February 1999

This edition of the NASA Reliability Preferred Practices and Guidelines incorporates the sixth, seventh and eighth supplements to the initial issue of September, 1991. Only Practice #1408 has been updated from the preceding set of 111 practices. The remaining material represents 54 new practices with over 300 pages of heritage design and test information.

A new category of practices for Ground Support Equipment was added in supplement 5 as "Section IV, Ground Support Equipment (GSE) Practices." These practices follow a less complex numbering convention and use only the prefix "GSE" followed by "-3XXX.".

A paper copy of the full set of practices is now available, but, in the light of paper reduction, use of the web-based edition is strongly recommended. However, limited copies of the paper version may be obtained from

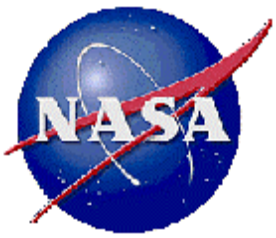
National Aeronautics and Space Administration
Code QS
300 E Street, SW
Washington, DC 20546

and from your local NASA Center via the Center Contacts listed on page v. Access through the web at http://www.hq.nasa.gov/office/codeq/overvu.htm is the most efficient way to access this information.

NASA Technical Memorandum 4322A

NASA Reliability Preferred Practices for Design and Test

NASA Reliability and Maintainability
Steering Committee
NASA Office of Safety and Mission Assurance
Washington, D.C.



National Aeronautics and
Space Administration

Office of Management

Scientific and Technical
Information Program

February 1999 **(Updated with Supplements 1(1992), 2 (1993), 3 (1994), 4 (1995), 5(1995), 6(1996), 7(1997), and 8(1998)**

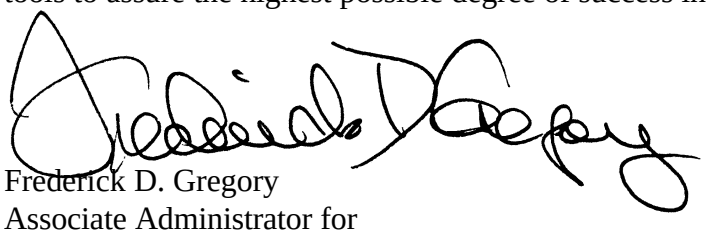
PREFACE

This manual summarizes reliability experience from both NASA and industry. It is intended to reflect engineering principles to support current and future civil space programs.

Reliability must be an integral part of the systems engineering process. The application of sound reliability principles will be the key to an effective and affordable American space program. Experience with our space programs has shown that reliability efforts must focus on the design characteristics that affect frequency of failure. This manual emphasizes that these identified design characteristics must be controlled through the application of conservative engineering principles.

I strongly encourage the use of this manual to assess your current reliability techniques. The manual should promote an active technical interchange between reliability and design engineering that focuses on the potential impact of design margin on maintenance and logistics requirements.

This manual is intended to be a dynamic medium for technical communication. Additional practices and guidelines will be published periodically. This manual should be considered a series of technical memoranda for promoting a systematic approach to the reliability discipline. These practices and guidelines provide the engineering community with useful tools to assure the highest possible degree of success in the Nation's civil space program.



Frederick D. Gregory
Associate Administrator for
Safety and Mission Assurance

NASA Wins IEEE Reliability Society "Company of the Year" Award

NASA and the USAF Rome Laboratory were co-recipients of the Institute of Electrical and Electronics Engineers Reliability Society's first "Company of the Year" Recognition Award at the Society's Annual Awards Banquet in Anaheim, California on January 18, 1998.

In her letter to NASA's Administrator, IEEE Reliability Society President, Loretta Arellano noted,

"NASA's development and placing of the "NASA Reliability Preferred Practices for Design and Test" and the "Recommended Techniques for Effective Maintainability" on the World Wide Web has made available an excellent heritage compendium of aerospace design information to the engineering community. Although the title implies that the information contained in these electronic data sources is the stereotypical "multiple nines" information, I was pleased to find it actually contains engineering design and test information that has lead to the development and launching of the highly successful projects with which our country's Space Agency has distinguished itself and the nation. This information is useful not only to the Product Assurance disciplinarians, but more importantly to the design and test engineers by putting design for mission success information in their language and supplying them with the appropriate tools. "

The Inscription Reads:

THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.
RELIABILITY SOCIETY
presents the
COMPANY RECOGNITION AWARD
to
NASA

This is to recognize NASA for the "NASA Reliability Preferred Practices for Design and Test" and the "Recommended Techniques for Effective Maintainability." These heritage sources openly share essential success knowledge that might otherwise be lost as the technical workforce changes. This is truly the essence of NASA's "Faster, Better, and Cheaper" goal.

Anaheim, CA
18 January 1998

Loretta Arellano
President, IEEE Reliability Society

CENTER CONTACTS

In the preparation of this manual, the dedication, time, and technical contributions of the following individuals are appreciated. Without the support of their individual centers, and their enthusiastic personal support and willingness to serve on the NASA Reliability and Maintainability Steering Committee, the practices and guidelines contained in this manual would not be possible.

All of the NASA Centers were invited to contribute to this manual. The people listed below may be contacted for more information about these practices and guidelines.

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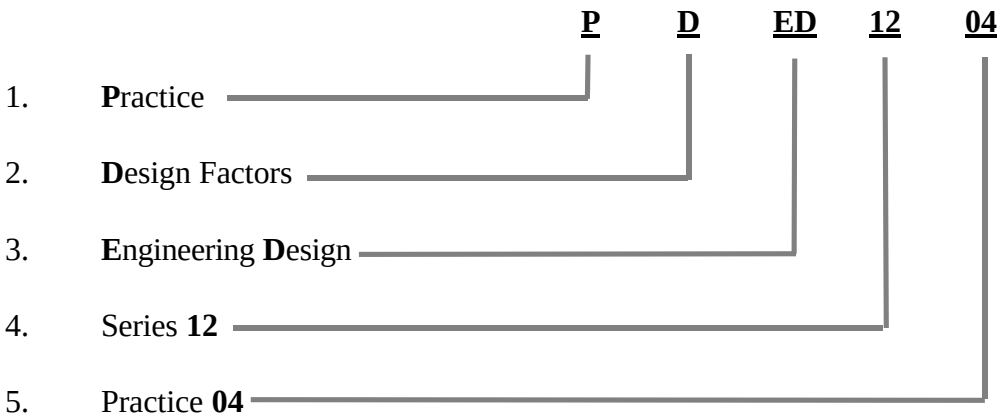
DOCUMENT REFERENCING

The following shows the document numbering system[1] applicable to these practices and guidelines. The example illustrated here is "Part Junction Temperature," Practice No. PD-ED-1204.



Key to Nomenclature

Position	Code
1.	G - Guideline P - Practice
2.	D. - Design Factors T - Test Elements
3.	EC - Environmental Considerations ED - Engineering Design AP - Analytical Procedures TE - Test Considerations & Procedures
4.	x - Series Number
5.	xx - Practice Number within Series

[1]A separate category of practices for Ground Support Equipment was added in supplement #5. These practices follow a less complex numbering convention and use only the prefix "GSE" followed by "-3XXX."

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OVERVIEW

A. PURPOSE

This manual is produced to communicate within the aerospace community design practices that have contributed to NASA mission success. The information presented has been collected from various NASA field centers and reviewed by a committee consisting of senior technical representatives from the participating centers.

B. APPLICABILITY

The information presented in this manual represents the "best technical advice" that NASA has to offer on reliability design and test practices. The practices contained in this manual should not be interpreted as requirements, but rather as proven technical approaches that can enhance system reliability. Application of the practices and guidelines is strongly encouraged, but the final decisions regarding applicability resides with the particular program or project office

The manual is divided into three technical sections. Part I contains reliability practices, including design criteria, test procedures, and analytical techniques that have been successfully applied on previous space flight programs. Part II contains reliability guidelines, including techniques currently applied to space flight projects where insufficient information exists to certify that the technique will contribute to mission success. Part III contains design, test, and procedural practices that have contributed to successful ground support of space flight and ground-based aerospace programs.

C. DISCUSSION

Experience with NASA's successful extended duration space missions shows that four fundamental elements contribute to high reliability:

1) Understanding stress factors imposed on flight hardware by its operating environment;

2) Controlling the stress factors through selection of conservative design criteria;

3) Appropriate analysis to identify and track high stress points in the design (prior to qualification testing or flight use); and

4) Careful selection of redundancy alternatives that will provide the necessary function(s) should failure occur.

This manual is provided to encourage design, test, and reliability engineers to give careful attention to both redundancy and management of stress factors during the design and development of space flight systems.

D. CONTROL/CONTRIBUTION

The practices and guidelines contained in this manual serve as a mechanism for communicating the latest techniques that contribute to high reliability. This publication will be revised periodically to include additional practices/guidelines, or revisions to information (as additional technical data becomes available). Contributions from aerospace contractors and NASA Field centers is encouraged. Any practice, guideline or technique that appears appropriate for inclusion in this manual should be submitted for review. Submissions should be formatted identically to the practices and guidelines in this manual and sent to the address below for consideration:

National Aeronautics and Space Administration
Code QS
300 E Street, SW
Washington, DC 20546

Organizations submitting practices/guidelines that are selected for inclusion in this manual will be recognized in the lower right-hand corner of the published item.

PART I: RELIABILITY PRACTICES

A. INTRODUCTION

This section contains Reliability Design Practices that have contributed to the success of previous space flight programs. The information presented in this section is for use throughout NASA and the aerospace community to assist in the design and development of highly reliable equipment and assemblies. The practices include recommended analysis procedures, redundancy considerations, parts selection, environmental requirements considerations, and test requirements and procedures.

B. RELIABILITY DESIGN PRACTICE FORMAT DEFINITIONS

The format for the reliability practices is shown below.

PRACTICE FORMAT DEFINITIONS

Practice: *A brief statement of the practice*

Benefit: *A concise statement of the technical improvement realized from implementing the practice*

Programs That Certified Usage: *Identifiable programs or projects that have applied the practice*

Center to Contact for More Information: *Source of additional information, usually the sponsoring NASA Center. See "CENTER CONTACTS", page v*

Implementation Method: *A brief technical discussion that is not intended to give the full details of the process, but rather to provide a design engineer with adequate information to understand how the practice should be used.*

Technical Rationale: *A brief technical justification for the use of the practice*

Impact of Nonpractice: *A brief statement of what can be expected if use of the practice is avoided*

Related Practices: *Identification of other topic areas in the manual that contain related information*

References: *Publications that contain additional information about the practice*

SPONSOR OF PRACTICE

PART II: RELIABILITY DESIGN GUIDELINES

A. INTRODUCTION

This section contains Reliability Design Guidelines for consideration by the aerospace community. The guidelines presented in this section contain valuable information that in the opinion of the sponsoring activity, represents a technically credible process that could be applied to ongoing NASA programs/projects. Unlike a Reliability Design Practice, a guideline lacks specific operational experience or data to indicate that a topic area has contributed to mission success. However, a guideline does contain information that represents current "best thinking" on a particular topic and is a well thought out approach to resolving a particular issue or problem. There is a unanimous Reliability and Maintainability Steering Committee agreement with the appropriateness of application of the approach.

B. RELIABILITY GUIDELINE FORMAT DEFINITIONS

The format for the reliability guidelines is shown below

GUIDELINE FORMAT DEFINITIONS

Guideline: *A brief statement of the guideline*

Benefit: *A concise statement of the technical improvement realized from implementing the guideline*

Center to Contact for More Information: *Source of additional information, usually the sponsoring NASA Center. See "CENTER CONTACTS", page iii*

Implementation Method: *A brief technical discussion that is not intended to give the full details of the process, but rather to provide a design engineer with adequate information to understand how the guideline should be used.*

Technical Rationale: *A brief technical justification for the use or the guideline*

Impact of Nonpractice: *A brief statement of what can be expected if use of the guideline is avoided*

Related Practices: *Identification of other topic areas in the manual that contain related information*

References: *Publications that contain additional information about the guideline*

SPONSOR OF GUIDELINE

PART III: GROUND SUPPORT EQUIPMENT (GSE) PRACTICES

A. INTRODUCTION

This section contains design and procedural practices that have contributed to successful ground support of space flight and ground-based aerospace programs. The information presented in this section is for use throughout NASA and the aerospace community to assist in the design, development, and operation of highly reliable ground support equipment and assemblies. This material is primarily concerned with design and test techniques, procedures for control of critical items, and control of environmental influences on successful launch.

B. RELIABILITY DESIGN PRACTICE FORMAT DEFINITIONS

The format for the reliability practices is shown below.

PRACTICE FORMAT DEFINITIONS

Practice: *A brief statement of the practice*

Benefit: *A concise statement of the technical improvement realized from implementing the practice*

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SPONSOR OF PRACTICE